GROWTH OF MACROPHYTES IN COOK'S BAY, LAKE SIMCOE

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ABSTRACT

In 1987, the Cook's Bay macrophyte community was surveyed to provide a comparison to the 1984 macrophyte survey results to determine if reduced nutrient input to Cook's Bay had produced changes in macrophyte growth.

The 1987 survey followed closely the methodology used in the 1984 survey. An addition to the 1987 survey was the collection of macrophytes from different trophic areas of Lake Simcoe to determine if plant tissue nutrient content reflected the nutrient availability of those areas.

Areal coverage of both discontinuous and continuous macrophyte growth increased from 1984. Coverage of continuous growth increased by 81 ha while discontinuous growth coverage increased by 105 ha. Total areal coverage of macrophytes was estimated to be 1,139 ha. Total macrophyte biomass increased by 55% from 1984 to 1987. Phosphorus and nitrogen tissue content of various macrophyte species was 0.21% and 2.20%, respectively, on an ash free, dry mass basis which was a decrease of 41% and 25%, respectively, as a response to decreased nutrient input to Cook's Bay.

Macrophyte species from Georgina Island and Atherley Narrows showed no difference in nutrient content compared with the same species from Cook's Bay. Data suggests that nutrient availability to the plants is now uniform throughout the lake.

Evidence of the presence of the caterpillar moth, *Acentria nivea*, believed to be responsible for the reduction of milfoil in the Kawartha Lakes was not found on macrophytes from Cook's Bay, Atherley Narrows or Georgina Island. The unknown "fine leaf" pondweed reported in the 1984 survey was identified as *Potamogeton pectinatus*.

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INTRODUCTION

In 1984, a comprehensive survey of aquatic plant growth in Cook's Bay, Lake Simcoe was conducted to determine the aquatic plant distribution, species composition, biomass and nutrient resources contained in the Cook's Bay macrophyte biomass (Limnos, 1985).

Also in 1984, treated sewage effluent from the communities of Newmarket and Aurora was diverted from the Lake Simcoe watershed to Lake Ontario. It was anticipated that the diversion of sewage effluents from Cook's Bay would significantly reduce the amount of nutrients available to aquatic biota in the Bay, and eventually, the main basin of Lake Simcoe. The documentation of macrophyte growth in Cook's Bay prior to the sewage effluent diversion provided baseline information for which changes in macrophyte status over time could be determined.

In 1987, a second survey of aquatic plant growth in Cook's Bay was conducted with the principle objective to determine if changes in aquatic plant distribution, biomass and contained nutrient content of macrophytes had occurred since the 1984 survey.

In order for an accurate comparison to be made, the timing of the study and methods established in 1984 were replicated as best as possible in 1987. Previously surveyed transects were repeated and the same biomass sites sampled in 1984 were sampled in 1987. The use of Loran C navigation technology was central in enabling field staff to successfully replicate transects and return to the 1984 sampling sites.

During the 1984 survey, samples of different macrophyte species were collected from various locations radiating away from the mouth of the

Holland River. These samples were analysed for nutrient content to determine if macrophytes distant from the mouth of the Holland River contained less nutrients than samples collected near the mouth of the river. Since the Holland River is a major source of nutrients for Cook's Bay it may have been expected that macrophytes proximal to this nutrient source may have contained higher concentrations of tissue nutrients than plant samples collected farther away from the mouth of the Holland River. However, no significant differences in plant tissue nutrient content was observed between plants collected near the river mouth and those collected at more distant locations in the Bay.

Instead of repeating this component of the study in 1987, samples of indicator macrophyte species were collected from Cook's Bay and less nutrient enriched locations in Lake Simcoe to determine if macrophyte tissue nutrient content reflected nutrient availability on a lake-wide basis.

OBJECTIVES

In order to document the status of the macrophyte growth in Cook's Bay, the following objectives were determined:

1) To determine the distribution, species composition, biomass and tissue nutrient content of macrophytes in Cook's Bay.

2) To compare 1984 and 1987 tissue nutrient data from Cook's Bay to determine if macrophyte tissue nutrient concentrations have been reduced.

3) To determine if the reduced nutrient input to Cook's Bay from the Holland River since 1984 has brought about changes to the Cook's Bay macrophyte community.

4) To determine if nutrient availability in less eutrophic areas of the main lake environment is reflected in the tissue nutrient content of macrophytes in those areas.

METHODS

Macrophyte Distribution

In order to document macrophyte distribution in the southern end of Cook's Bay, a series of transects were run from Marker Buoy SS19, located 1100 m north of the mouth of the Holland River. Transects radiated from the buoy at 10^0 intervals and ended at shoreline locations, or where plant growth ceased due to water depth. Field notes from the 1984 survey provided Loran C co-ordinates along each transect, and using a Loran C navigational unit, field personnel were able to follow and replicate the course of the original transects. A hand held compass provided an initial bearing for each transect.

A twenty foot barge equipped with a 60 hp outboard motor was used for running transects. As in the 1984 study, a Raytheon Recording Fathometer (Model DE-719C) was used to record water depth, presence or absence of plant growth in the water column, and plant abundance.

Loran C co-ordinates were recorded at regular intervals along each transect and the co-ordinate recorded directly onto the chart paper. Co-ordinates were also recorded along each transect to document locations where plant growth ceased, began, or became discontinuous, as well as the end points of transects.

Macrophyte Biomass and Species Composition

During the 1984 survey, 42 biomass samples were collected along eight of the survey transects, and Loran C co-ordinates recorded for each sampling point. Biomass samples were collected at the same

locations in 1987. During the course of running transects, anchored buoys were dropped at sampling points located by Loran C, and field personnel subsequently returned to the marked points for biomass sampling.

To collect biomass samples, a skin or scuba diver collected all plant material above the sediment contained in a 0.25 m^2 quadrant. At each sampling location, plant growth was collected from three random quadrants, and combined to form the biomass sample.

Species in the sample were identified by a qualified biologist, and the species composition of the sample estimated on a percentage basis. The collected plants were placed in marked plastic bags and stored on ice in a cooler. To measure biomass, samples were spun in a hand operated kitchen salad spinner to remove surficial waters from the plants. Use of a salad spinner for this purpose has been described elsewhere (Limnos, 1987). The fresh mass of the sample was subsequently determined using a triple beam balance (normally at dockside) and the volume of the sample determined by water displacement in a graduated cylinder.

In 1984, a relationship between wet volume and ash free, dry mass was developed such that the volume of a biomass sample could be used to estimate the ash free, dry mass (Limnos, 1985). In 1987, this methodology was repeated so that the calculation of total volume of plant biomass in Cook's Bay could be used to estimate total ash free dry mass. Twenty representative biomass sub-samples were retained for this purpose. The volume and wet mass were determined for each sample. The samples were subsequently air dried, the dry mass recorded, and then submitted to Barringer Magenta laboratories for determination of organic content.

Macrophyte Tissue Nutrients

As mentioned in the previous section, representative biomass samples were collected for tissue nutrient analysis. As well, 5 samples of milfoil (Myriophyllum spicatum), muskgrass (Chara sp.), bushy pondweed (Najas flexilis), coontail (Ceratophyllum demersum) and Canada waterweed (Elodea canadensis) were collected from Cook's Bay for tissue nutrient analysis to provide a comparison with tissue nutrient content of the same species from the 1984 survey.

Samples of the above mentioned species were also collected from the area around Atherley Narrows and from the channel separating Georgina Island from the mainland which are considered less nutrient enriched sites of the lake compared to Cook's Bay (MOE, 1982). Tissue nutrient content of macrophytes between the three sites were compared to determine if trophic status at the different sites is reflected in the plant nutrient content.

RESULTS

Macrophyte Distribution

Distribution survey transects were run as described in the methods and the locations of the transects were the same as those surveyed in 1984 (Limnos, 1985). The echo-tracings in conjunction with the Loran C co-ordinates were used to determine the areal distribution of macrophyte growth in Cook's Bay. Areal coverage of discontinuous and continuous macrophyte growth is found in Figure 1. The area of continuous growth in Cook's Bay was estimated to cover 588 ha while the area of discontinuous growth was estimated to cover 551 ha for a total macrophyte areal coverage of 1139 ha. This is an increase of 186 ha from 953 ha of macrophyte coverage estimated in 1984.

Plant growth was classified as being discontinuous or continuous following examination of echo-tracings. Continuous growth occurred where few breaks in plant cover were observed, and discontinuous growth occurred where breaks in plant growth were more frequent (Limnos, 1985). A sample echo-tracing is presented in Figure 2a and 2b to demonstrate the differences between continuous and discontinuous growth, respectively, as recorded by the Raytheon fathometer.

The continuous growth portion indicates a dense cover of plants with very few breaks (Figure 2a). The plants are taller (3 m) and are growing at a depth of 5.5 m. As the bottom contour changes and the depth increases the density of plants is less and more breaks in plant cover are evident (Figure 2b). The plants at these greater depths are not as tall (1.5) as plants in the continuous growth portion of the tracing.

In general, discontinuous growth occurred in exposed shallow areas

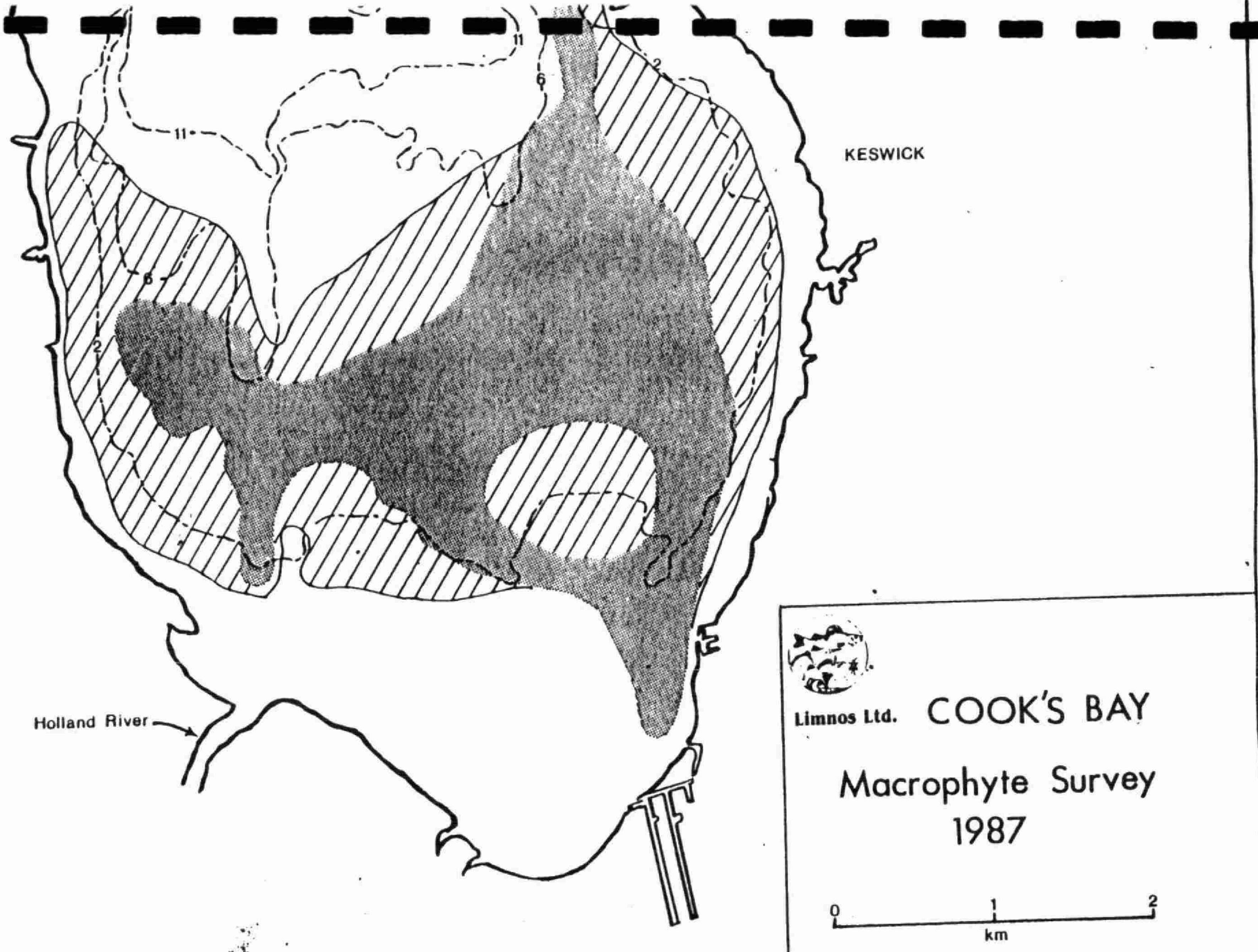
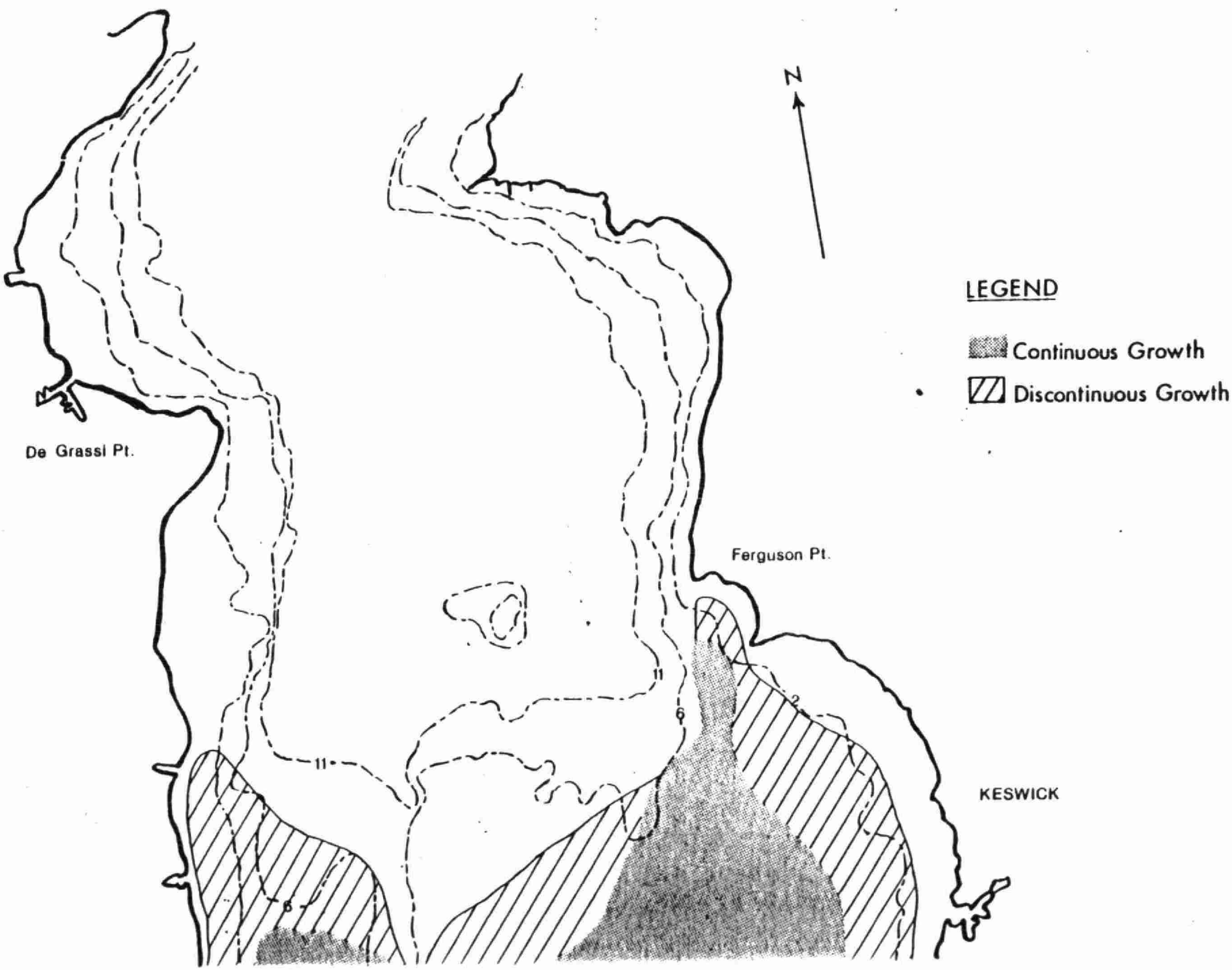


Figure 1 – Areal Coverage of Continuous and Discontinuous Growth of Macrophytes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SAMPLE ECHO CH

Figure 2a. Echo-tracing of Continuous Macrophyte Growth.

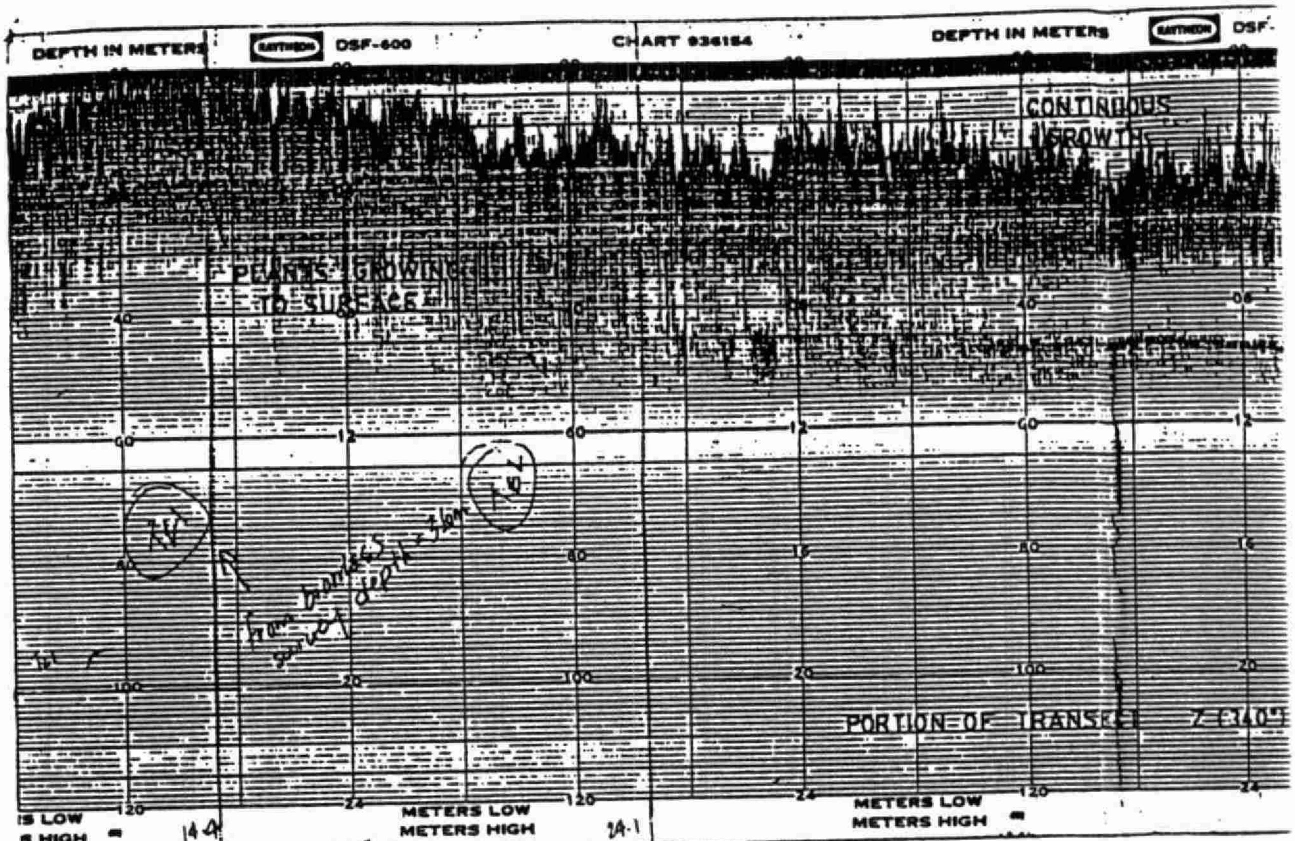
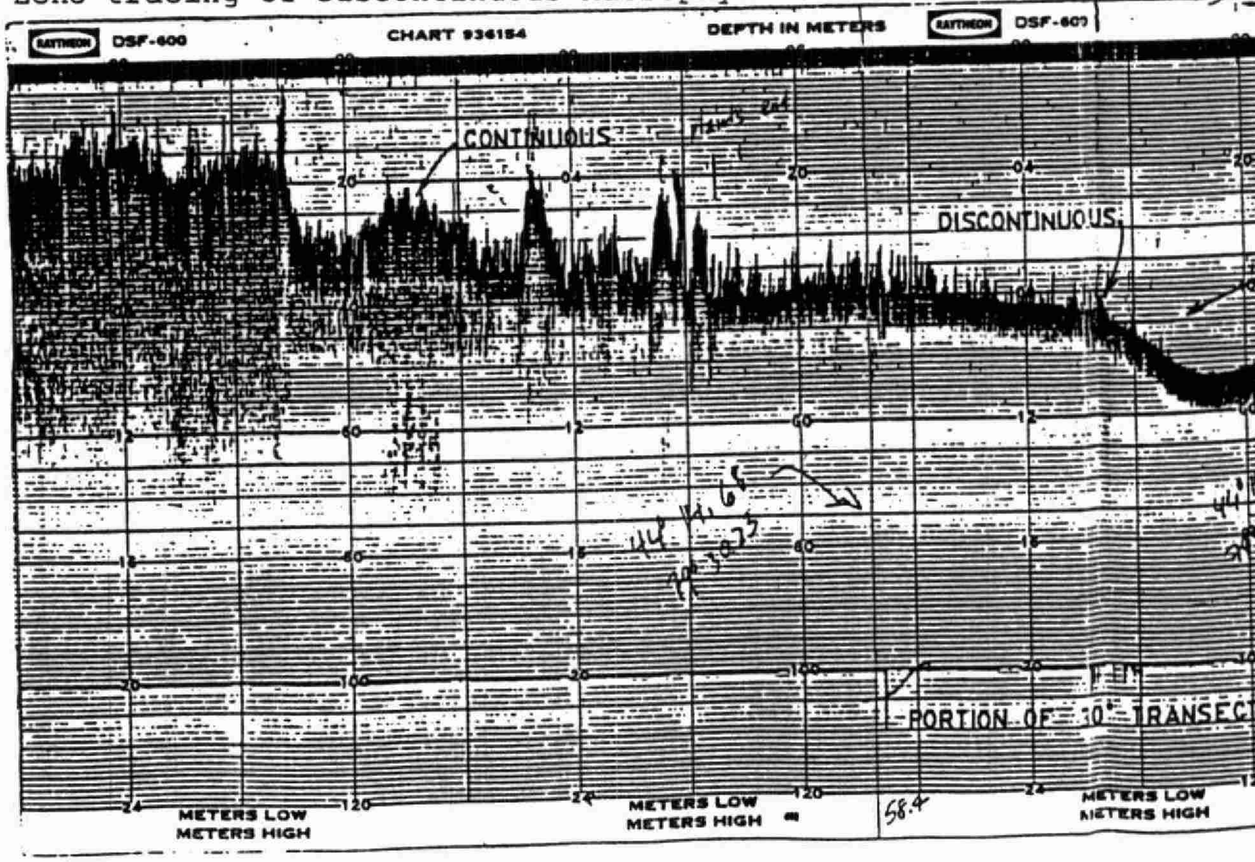
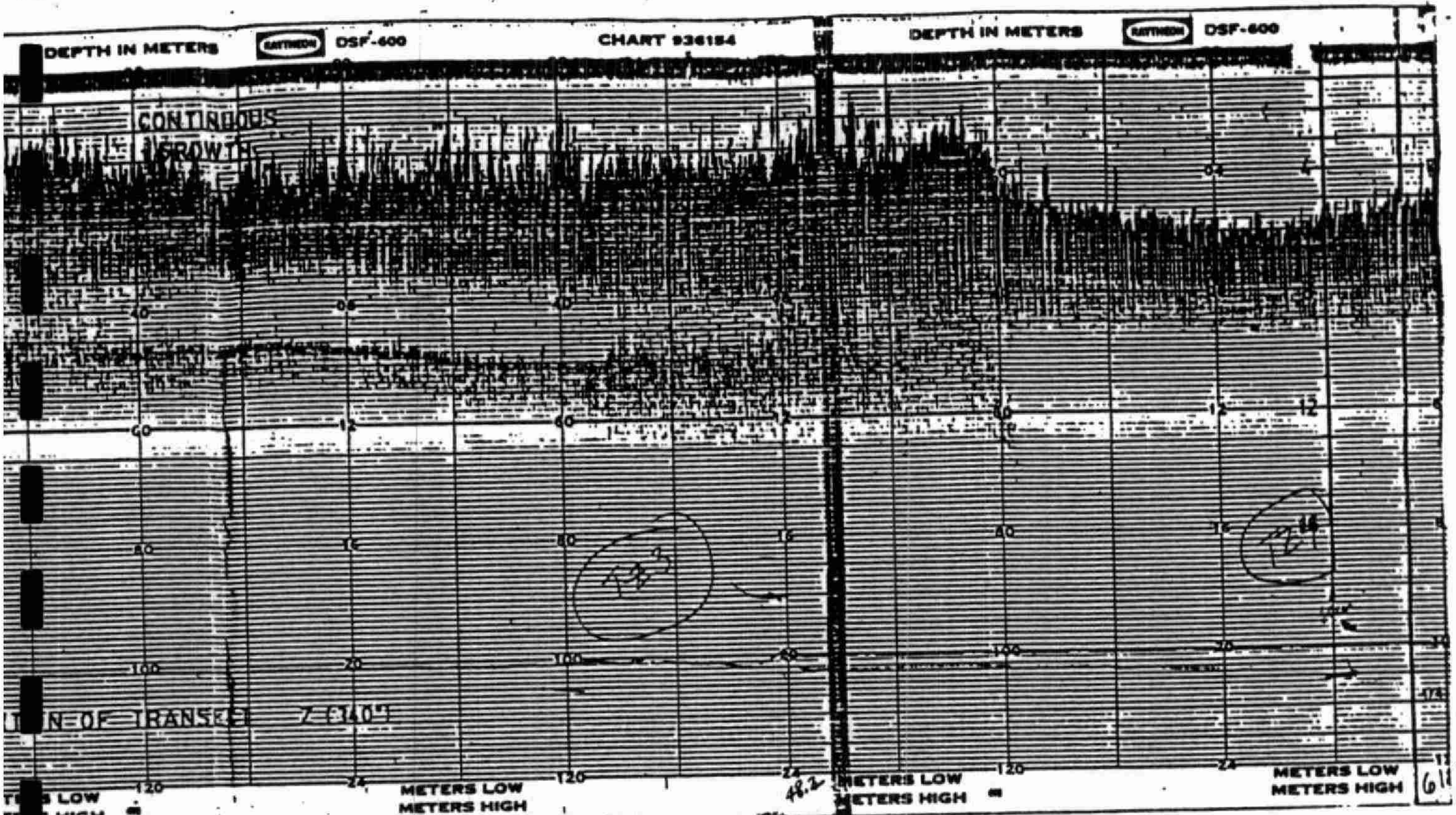


Figure 2b. Echo-tracing of Discontinuous Macrophyte Growth.



SAMPLE ECHO CHARTS



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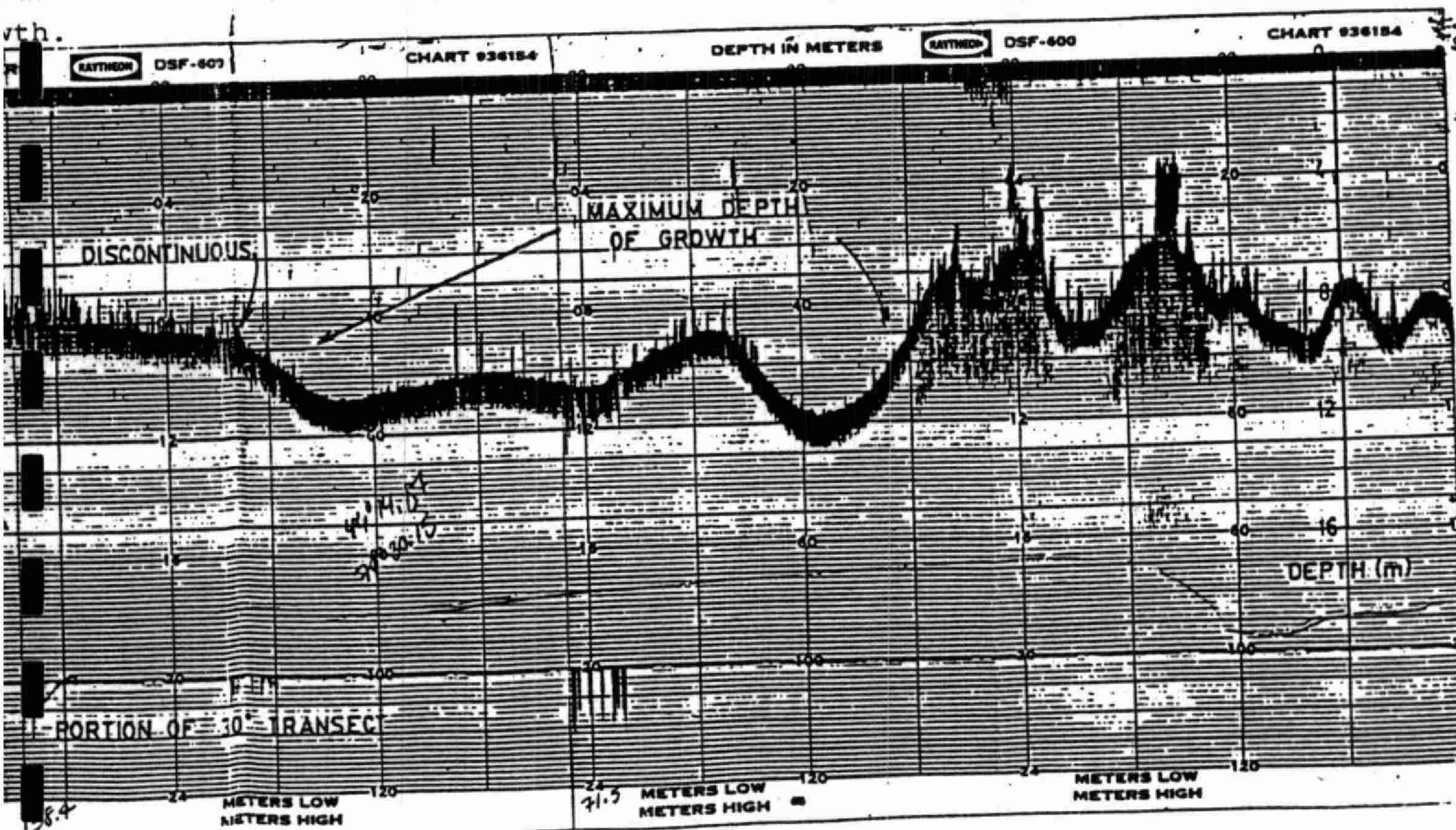


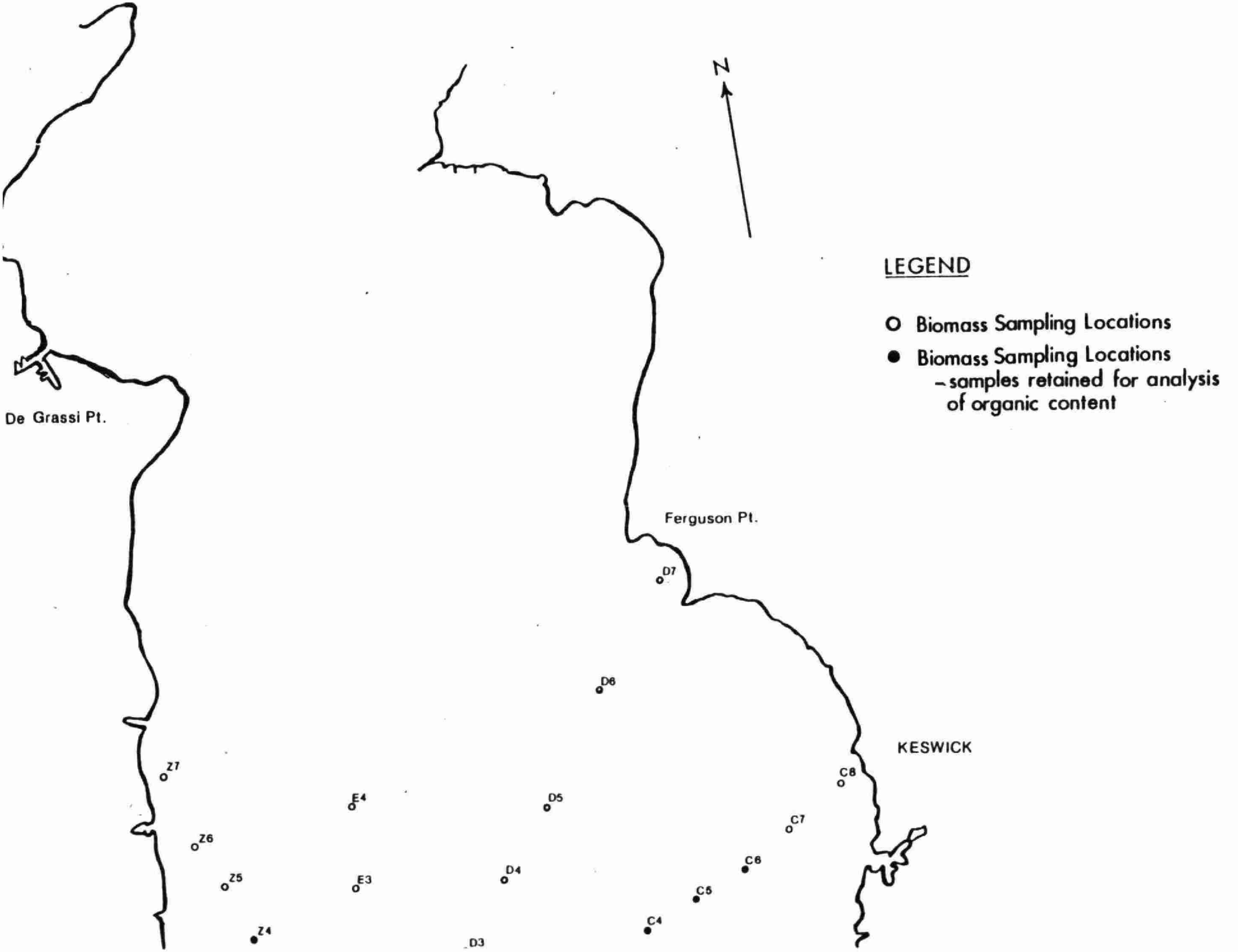
less than 2 m deep, and in waters deeper than 5.5 m. Continuous growth was generally found in moderate depths extending from 2 to 4.5 m.

Macrophyte Biomass and Species Composition

The location of biomass sampling sites are presented in Figure 3. A summary of results of biomass sampling is presented in Table 1. The results of all biomass sampling sites and species composition can be found in Appendix A. Continuous growth had an average biomass of 1,200 g/m^2, while discontinuous growth had an average biomass of 430 g/m^2.

Biomass sampling site Z7, consisting of 100% Chara, had a biomass of 10,092 g/m^2. Because this value is a magnitude larger than the other discontinuous growth biomass values, it was not included in the determination of average biomass. Twenty biomass samples were retained to determine the relationship between wet volume and AFDM (ash free dry mass) such that a total volume measurement occupied by plants could be used to predict total AFDM. The results of the analysis are presented in Table 2.

Species composition of biomass samples in 1987 was similar, for the most part, to samples examined in 1984. One difference noted was a greater frequency and abundance of Heteranthera dubia in 1987 samples. Potamogeton pectinatus was less frequent and abundant in 1987 samples. In many of the biomass samples dominated by Chara in 1984, samples from the same sites in 1987 indicated a lesser abundance of Chara, with an increase in the abundance of other macrophytes. However, Chara usually maintained a large percentage of the species composition of those samples (Appendix A).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Biomass Sampling Locations
Biomass Sampling Locations
- samples retained for analysis of organic content
De Grassi Pt.
Ferguson Pt.
KESWICK
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Z7
E4
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C8
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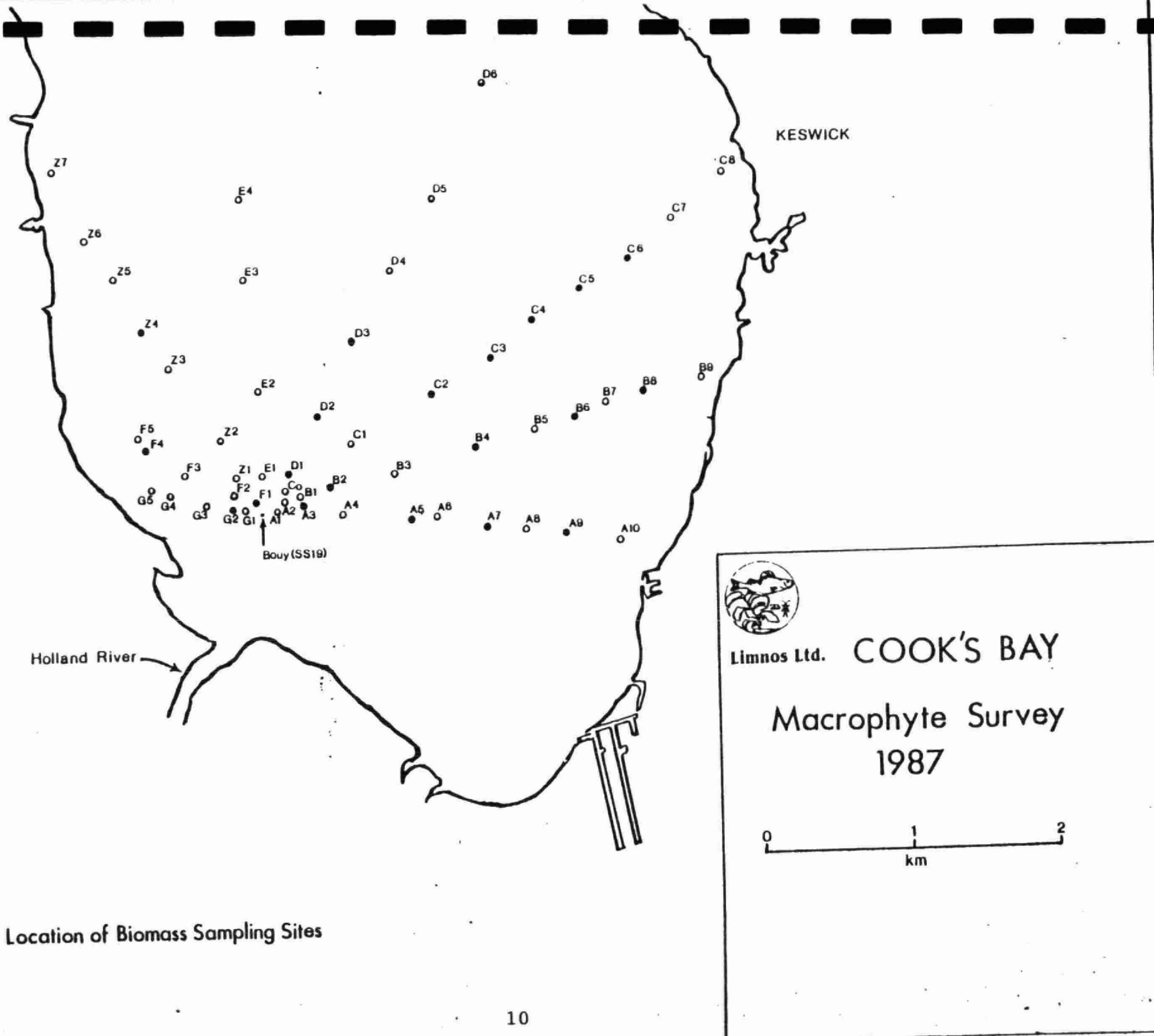

Figure 3 - Location of Biomass Sampling Sites

Table 1. Comparison of Results of 1984 and 1987 Cook's Bay Macrophyte Surveys.

Parameters	1984	1987
Area of discontinuous growth	446 ha	551 ha
Area of continuous growth	507 ha	588 ha
Total coverage	953 ha	1139 ha
Discontinuous growth biomass	196.6 ml/m^2	369 ml/m^2 (430 g/m^2)
Continuous growth biomass	786 ml/m^2	1,270 ml/m^2 (1,200 g/m^2)
Total biomass	4.81×10^9 m	10.5×10^9 ml (8,969 tonnes)
Average %P on an ash free dry basis	0.36	0.21
Total P in Cook's Bay macrophytes	920 kg	1,169 kg
Average %N on an ash free dry basis	2.87	2.20
Total N in Cook's Bay macrophytes	7,310 kg	12,250 kg

Table 2. Wet Volume, Wet Mass, and Ash Free Dry Mass Values from Cook's Bay Biomass Samples.

Biomass Station	Wet Volume (ml)	Wet Mass (g)	Dry Mass (g)	Organic Content %	Ash Free Dry Mass (g)	Dry Mass / Wet Mass
A3	165	151	20.1	53.93	10.84	0.13
A5	195	198	34.4	37.35	12.85	0.17
A7	385	377	60.4	40.88	24.69	0.16
A9	1695	1463	156.8	54.13	84.88	0.11
B2	210	183	24.8	34.16	8.47	0.14
B4	150	149	23.7	33.37	7.91	0.16
B6	120	127	15.5	53.54	8.30	0.12
B8	178	164	12.6	61.81	7.79	0.08
C2	140	144	19.3	72.58	14.01	0.13
C3	97	133	29.8	47.17	14.06	0.22
C4	100	110	16.6	78.00	12.95	0.15
C5	225	220	13.7	71.53	9.80	0.06
C6	195	187	20.2	61.38	12.40	0.11
D1	120	130	34.3	34.04	11.68	0.26
D2	110	122	24.1	42.93	10.35	0.20
D3	186.5	165	53.0	25.53	13.53	0.32
F1	38	34	5.6	74.98	4.20	0.16
F4	65	81	23.5	39.45	9.27	0.29
G2	176	172.5	22.0	75.02	16.50	0.13
Z4	128	122.5	16.0	73.58	11.77	0.13

Macrophyte Tissue Nutrients

Frozen samples of Chara, coontail, milfoil, and Canada waterweed from Cook's Bay were analyzed for contained tissue nutrients. The results are presented in Table 3. Average phosphorus and nitrogen content in plants collected was 0.21% and 2.20%, respectively, on an ash free, dry mass basis.

All of the species analyzed had a lower phosphorus content in 1987 compared to 1984 (0.37%). Chara demonstrated the largest decrease as phosporus content dropped from 0.51% to 0.23%. Milfoil also showed a significant decrease in phosphorus content from 0.35% to 0.19% on an ash free dry mass basis.

Nitrogen content was also observed to decrease from 1984 (2.9% AFDM) to 1987. Milfoil, Canada waterweed and Chara demonstrated a decrease in nitrogen content while coontail showed an increase.

Tissue nutrient analysis results of macrophyte species from Georgina Island and Atherley Narrows indicate that there was no significant difference in phosphorus and nitrogen content between the three sites (Table 3). Average phosphorus and nitrogen content for Georgina Island and Atherley Narrows were 0.19% and 1.89% and 0.22%, and 2.25%, respectively, on an ash free, dry mass basis. Only coontail at Georgina Island showed a lesser phosphorus and nitrogen content. Phosphorus and nitrogen content for coontail were 0.12% and 1.6% respectively, on an ash free dry basis compared to 0.26% and 2.7% for phosphorus and nitrogen respectively, from Cook's Bay and, 0.24% and 2.53% for phosphorus and nitrogen respectively from Atherley Narrows.

Organic content for all species, except Chara, was consistently low

Table 3. Tissue Nutrient Analysis Results for Macrophytes in Cook's Bay, Georgina Island and Atherley Narrows Areas Expressed as a Percentage of Ash Free Dry Mass.

	Cook's Bay 1984				Cook's Bay 1987					Georgina Island					Atherley Narrows				
Species	n	LOI (%)	P (%)	N (%)	n	LOI (%)	P (%)	N (%)	K (%)	n	LOI (%)	P (%)	N (%)	K (%)	n	LOI (%)	P (%)	N (%)	K (%)
M. spicatum	4	44.3	0.35	2.8	5	38.14	0.19	2.50	0.83	5	67.02	0.2	2.64	1.41	5	39.57	0.21	2.41	1.45
C. demersum	5	71.3	0.36	2.2	5	81.10	0.26	2.70	3.40	5	80.41	0.12	1.60	1.96	3	47.18	0.24	2.53	2.69
E. canadensis	5	71.5	0.29	3.6	5	73.61	0.20	1.64	1.95	3	68.90	0.19	1.85	2.46	4	48.77	0.19	1.90	2.86
Chara	5	29.7	0.51	3.1	5	28.39	0.23	1.67	0.65	5	33.33	0.23	1.62	0.82	5	34.79	0.26	2.16	1.76
Najas					5	66.30	0.20	2.52	0.89	3	55.25	0.22	1.75	1.71					

at Atherley Narrows sites in comparison with LOI values for the same species at Georgina Island and Cook's Bay. Calcium carbonate deposits were evident on milfoil and Canada waterweed at Atherley Narrows and therefore may account for the low organic content of the plants at these sites.

CONCLUSIONS AND DISCUSSION

The macrophyte distribution and biomass survey both indicate that there has been an increase in macrophyte growth in Cook's Bay since 1984. The area of continuous growth increased from 507 ha to 550 ha, while the area of discontinuous growth increased from 446 ha to 551 ha. This represents a 186 ha increase in macrophyte areal coverage since 1984.

From 1984 to 1987, discontinuous growth total biomass increased by 1.15×10^9 ml, while continuous growth total biomass increased by 3.48×10^9 ml. This provided a total biomass increase of [illegible]$.69 \times 10^9$ ml, or 55%, from 1984 to 1987. An increase in biomass was observed in thirty-four of forty-four biomass sites in 1987 compared to the same sites in 1984 (Appendix A).

In 1987, the area south of Transect A, toward the end of the transect, was surveyed for the presence of macrophytes. The plant growth in this area added 38 ha to the estimate of areal coverage which added to the increase of total biomass estimate. This area was not surveyed in 1984 and therefore not included in the areal coverage. In 1987, with this addition, areal coverage of continuous growth was 588 ha.

On the basis of information obtained in 1987 an estimation of total phosphorus and nitrogen contained in the plants can be calculated. To estimate total AFDM, a regression relationship for volume and AFDM was determined and subsequently used to predict total organic biomass from total volume.

The following is the volume-AFDM relationship developed from results of the 1987 survey:

$$\text{Total AFDM} = 0.05303 \times \text{Total Volume} \quad (r^2 = 0.92)$$

Using the developed volume-AFDM relationship, total AFDM can be determined,

$$\text{Total AFDM} = 0.05303\ \text{g/ml} \times (10.5 \times 10^9\ \text{ml})$$
$$= 556.8 \times 10^3\ \text{kg}$$

From estimates of total ash free, dry mass, total phosphorus and nitrogen contained in the Cook's Bay macrophytes can be estimated.

$$\text{Total AFDM} \times \text{TP\% AFDM} = \text{kg of plant bound P}$$
$$556.8 \times 10^3\ \text{kg} \times 0.21\% = 1{,}169\ \text{kg P}$$
$$\text{Total AFDM} \times \text{TN\% AFDM} = \text{kg of plant bound N}$$
$$556.8 \times 10^3\ \text{kg} \times 2.20\% = 12{,}250\ \text{kg N}$$

The increase in total phosphorus and nitrogen from 1984 to 1987 contained in the plant growth of Cook's Bay is 249 kg and 4,940 kg, respectively (Table 1). The increase is a result of the significant increase in total biomass as well as the increase in areal coverage in spite of a decrease in phosphorus and nitrogen content in the plants.

It was noted that phosphorus tissue content determined from the dried biomass samples was slightly higher than the phosphorus content of frozen individual macrophyte species (0.27% vs. 0.21%). It has been recommended that plant samples submitted for tissue nutrient analysis be

dried rather than frozen, as the freezing process breaks the cell walls and causes leakage of elements from the tissue. This provides an underestimation of tissue nutrient content and therefore may account for the difference observed in phosphorus concentration between the dried biomass samples and the frozen tissue nutrient samples.

The diversion of sewage from the municipalities of Newmarket and Aurora beginning in 1984 was anticipated to reduce phosphorus input and slow eutrophication. Subsequently, a reduction in phosphorus would decrease algae growth during the growing season and improve water clarity, and as a result, provide a potential for an increase in macrophyte growth. The 1987 results, for the most part, support the hypothesized changes; reduction in the amount of phosphorus available to the plants, an increase in biomass and a limited increase in plant coverage. However, an increase in secchi depth in Cook's Bay during the limited sampling period was not observed in 1987.

Although a decrease in phosphorus content in the plants was observed in Cook's Bay in 1987, other regions of the lake which are less eutrophic did not demonstrate a lesser nutrient availability. It was anticipated that Georgina Island and Atherley Narrows, being less eutrophic sites, would have a lower nutrient availability which would be reflected in the plant tissues. However, this was not observed and as a result it is inconclusive if plant tissue nutrients from Atherley Narrows and Georgina Island, reflected nutrient availability.

It would appear that macrophytes in Cook's Bay have changed from a luxury uptake of nutrients to a consistent average value uptake on a whole lake basis. Current nutrient levels appear able to support good growth under appropriate conditions of light, depth and sediment type. However, phosphorus content of macrophytes in Cook's Bay averages

0.126%, on a dry mass basis, which seems to be approaching a range of phosphorus content values (Gerloff and Krombholz, 1966; Wilson, 1972) which would be limiting to macrophyte growth.

If further reductions in nutrients occur, without being limiting to growth, macrophyte density may increase. Since most shallow water habitat is colonized by macrophytes any extension of areal coverage would be expected to occur in deeper waters (>6 m). In 1987, healthy coontail plants were found growing at depths below 8 m which indicates that at least one species of macrophyte in Cook's Bay is capable of expanding into deeper waters.

During the 1987 macrophyte survey, biomass samples were examined for the presence of Acentria nivea, an aquatic moth caterpillar that is believed to be responsible for the reduction of milfoil in the Kawartha lakes (Painter and McCabe, 1987). No evidence of A. nivea damage to milfoil or any other macrophyte was found during the survey.

The larvae of A. nivea have a preference for the green apical tips of milfoil plants, but since milfoil is only a small percentage of the diverse macrophyte community in Cook's Bay, unlike the Kawartha lakes, there may not be enough biomass to support a population of A. nivea. It is also possible that A. nivea has yet to disperse into Lake Simcoe and would probably be limited to Cook's Bay where depth and sediments are suitable to support milfoil growth.

It is believed that A. nivea grazing on milfoil occurs synchronously with the two peaks of milfoil growth; May-June and September (Painter, 1987). Due to the timing of the 1987 survey, it is possible that A. nivea was undergoing larvae instar morphogenesis (Painter, 1987) and therefore grazing activity and subsequent evidence of damage to plants was not observed.

During the 1984 survey, a common macrophyte in biomass samples, designated as "P. fine", was not identified. In 1987, specimens of this species were collected, pressed, and dried for purposes of identification. The plant was identified by Limnos staff as Potamogeton pectinatus and verified by a botanist with the Botany Department, Royal Ontario Museum (TRT). The specimens of P. pectinatus found in Cook's Bay were long-stemmed and robust as opposed to narrow-leaved and bushy, which is the form commonly observed in southern Ontario lakes. This was observed by Voss (1972) in Michigan aquatic environments.

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Appendix A: Biomass Sampling Results - Cook's Bay Macrophyte Survey, 1987

Sample Station	Date	Depth (m)	Secchi Depth (m)	Loran C Co-ords	Wet Volume (ml/m^2)	Wet Mass (g/m^2)	Species Composition
A1	Aug. 10		0.75	16,054.6 58,981.4	0	0	
A2	Aug. 10	2.25	0.75	16,054.4 58,981.7	180	207	Chara - 50% Moss - 40% Najas - 5% H. dub V. am - 5%
A3	Aug. 10	2		16,054.5 58,982.4	220	201	H. dub - 70% Najas - 15% Chara - 10% C. dem V. am - 5%
A4	Aug. 10	2	0.8	16,054.6 58,983.8	127	143	H. dub - 70% Najas - 15% V. am - 5% Moss - 5% Chara - 5%
A5	Aug. 10	2.25		16,054.5 58,986.3	260	264	Chara - 50% V. am - 10% H. dub - 10% Najas - 10% P. pec - 10% C. dem - 10%
A6	Aug. 10	2		16,054.5 58,987.1	413	437	Chara - 55% V. am - 25% H. dub - 10% C. dem Najas - 10% Elodea
A7	Aug. 10	2	0.8	16,054.6 58,988.6	513	503	V. am - 40% Moss - 30% Chara - 15% P. pec - 10% Najas Elodea - 5%
A8	Aug. 10	2		16,054.6 58,990.2	1080	957	V. am - 50% H. dub - 30% C. dem - 10% Najas M. spic Chara - 10% P. pec

Appendix A (cont'd): Biomass Sampling Results - Cook's Bay Macrophyte Survey, 1987

Sample Station	Date	Depth (m)	Secchi Depth (m)	Loran C Coords.	Wet. Volume (ml/m^2)	Wet Mass (g/m^2)	Species Composition
A9	Aug. 10	1.75		16,054.6 58,991.8	2260	1950	V. am - 75% Chara - 15% P. pus P. pec - 10% Elodea
A10	Aug. 10	1.75		16,054.7 58,994.1	3000	2445	V. am - 95% M. spic - 5%
B1	Aug. 6	2.4	1	16,054.3 58,982.2	187	200	Chara - 45% Moss - 45% V. am H. dub Najas - 10% Elodea
B2	Aug. 6	2	1	16,054.0 58,983.3	693	587	M. spic- 90% H. dub Najas - 10% Elodea
B3	Aug. 6	2.5	1.1	16,053.6 58,985.6	560	571	Chara - 50% Moss - 30% V. am M. spic H. dub - 20% P. pec P. pus
B4	Aug. 6	2.6	1.4	16,052.9 58,988.5	593	568	Chara - 50% Moss - 25% P. pec - 15% C. dem Najas P. rich - 10% V. am
B5	Aug. 6	2.5	1.2	16,052.4 58,990.5	247	260	Chara - 60% Najas - 30% V. am H. dub - 10%
B6	Aug. 6	2.5	1.3	16,052.0 58,992.1	505	505	Chara - 50% V. am - 40% C. dem M. spic Najas - 10% P. rich

Appendix A (cont'd): Biomass Sampling Results - Cook's Bay Macrophyte Survey, 1987

Sample Station	Date	Depth (m)	Secchi Depth (m)	Loran C Coords.	Wet Volume (ml/m^2)	Wet Mass (g/m^2)	Species Composition
B7	Aug. 6	2.5	1.3	16,051.7 58,993.3	1520	1380	Chara - 65% V. am - 20% H. dub - 10% C. dem - 10% Najas Elodea - 5%
B8	Aug. 6	2.5	1.4	16,051.4 58,994.8	2345	1897	V. am - 75% H. dub - 20% Chara Elodea M. spic - 5% Najas
B9	Aug. 6	1.5	1.3	16,051.0 58,997.2	66.7	75	Najas - 70% Chara - 30%
Co	Aug. 6	2.2	1.1	16,054.2 58,981.8	167	220	Chara - 60% Moss - 15% M. spic - 15% H. dub Najas - 10%
C1	Aug. 6	2.5	1.4	16,053.0 58,984.0	600	595	Chara - 50% Moss - 20% V. am - 10% M. spic - 10% H. dub P. pec - 10%
C2	Aug. 6	3	1.8	16,051.8 58,986.8	1145	1257	Elodea - 25% C. dem - 25% Moss - 25% H. dub - 7% P. zost - 6% M. spic - 6% P. pec - 6%
C3	Aug. 6	3	1.4	16,050.9 58,988.9	613	610	Chara - 30% Moss - 30% Elodea - 20% P. rich - 5% V. am - 5% M. spic - 5% P. pec - 5%

Appendix A (cont'd): Biomass Sampling Results - Cook's Bay Macrophyte Survey, 1987

Sample Station	Date	Depth (m)	Secchi Depth (m)	Loran C Coords.	Wet Volume (ml/m^2)	Wet Mass (g/m^2)	Species Composition
C4	Aug. 6	3	1.4	16,050.0 58,990.4	800	772	C. dem - 25% P. pec - 25% Elodea - 25% Najas - 10% V. am - 5% Chara - 5% M. spic - 5% H. dub
C5	Aug. 6	3.5	1.5	16,049.2 58,992.2	745	717	C. dem - 80% P. zost- 5% P. pec - 5% P. pus - 5% Elodea - 5%
C6	Aug. 6	3	1.5	16,048.4 58,994.0	1000	881	C. dem - 18% H. dub - 18% Elodea - 17% M. spic- 17% P. pec - 17% P. zost- 17%
C7	Aug. 6	2.7	1.4	16,047.5 58,959.9	360	385	Chara - 66% Najas - 12% V. am - 12% P. pus - 5% C. dem - 5%
C8	Aug. 6	1.4	b	16,046.3 58,998.1	0	0	
D1	Aug. 5	2.5	0.9	16,053.8 58,991.8	220	248	Moss - 60% Chara - 30% V. am - 5% H. dub - 5%
D2	Aug. 5	3.1	0.9	16,052.6 58,982.8	1173	1060	Moss - 60% Elodea - 25% M. spic- 10% V. am C. dem - 5%
D3	Aug. 5	4.2	1.9	16,050.8 58,984.0	1540	1517	C. dem - 95% P. zost - 5% Elodea
D4	Aug. 5	6	2.1	16,049.1 58,985.3	0	0	

Appendix A (cont'd): Biomass Sampling Results - Cook's Bay Macrophyte Survey, 1987

Sample Station	Date	Depth (m)	Secchi Depth (m)	Loran C Coords.	Wet Volume (ml/m^2)	Wet Mass (g/m^2)	Species Composition
D5	Aug. 5	6	2.4	16,047.4 58,986.8	0	0	
D6	Aug. 5	6.75	2.7	16,045.1 58,988.6	0	0	
D7	Aug. 5	2.8	2.7	16,042.3 58,990.8	n.r.	1060	Chara - 90% M. spic Najas - 10% P. rich V. am
E1	July 31	3	1.5	16,053.9 58,980.9	0	0	
E2	July 31	4		16,052.0 58,980.6	1700	1756	C. dem - 65% Elodea - 35%
E3	July 31	8.5		16,049.6 58,980.0	0	0	
E4	July 31	7.2		16,047.8 58,980.0	0	0	
Z1	July 30	3.5		16,053.9 58,980.0	453	454	C. dem - 90% Elodea - 5% P. cris- 5%
Z2	July 30	3.6		16,053.2 58,979.3	1000	1040	C. dem - 90% Elodea - 5% P. zost- 5%
Z3	July 30	4		16,051.7 58,977.5	1367	1437	C. dem - 45% M. spic- 45% Elodea P. cris- 10% P. zost

Appendix A (cont'd): Biomass Sampling Results - Cook's Bay Macrophyte Survey, 1987

Sample Station	Date	Depth (m)	Secchi Depth (m)	Loran C Coords.	Wet Volume (ml/m^2)	Wet Mass (g/m^2)	Species Composition
Z4	July 30	5	2.5	16,050.9 58,976.5	2140	2190	C. dem - 70% M. spic- 25% Elodea - 5%
Z5	July 30	4	2.	16,049.9 58,975.5	1547	1773	C. dem - 95% Elodea - 5%
Z6	July 30	3	2.5	16,049.1 58,974.5	800	776	Chara - 14% M. spic- 14% V. am - 14% Moss - 14% Najas - 14% Elodea - 14% Utric - 14%
Z7*	July 30	1.75		16,047.7 58,973.3	8860	10092	Chara - 100%

* results based on only one quadrant

Sample Station	Date	Depth (m)	Secchi Depth (m)	Loran C Coords.	Wet Volume (ml/m^2)	Wet Mass (g/m^2)	Species Composition
F1	July 28	2.5		16,054.5 58,980.7	67	70	P. pec - 80% H. dub - 10% Elodea - 10%
F2	July 28	2.4	b	16,054.4 58,979.8	2833	2921	C. dem - 90% Elodea - 5% M. spic- 5%
F3	July 28	2.7		16,054.0 58,978.1	333	399	Chara - 100%
F4	July 28	2.6	b	16,053.5 58,977.0	467	543	Chara - 60% Moss - 30% P. rich V. am - 10%
F5	July 28	2.5		16,053.3 58,976.4	987	1180	Chara - 100%
G1	July 27	2.7	b	16,054.7 58,980.3	207	213	H. dub - 60% C. dem - 20% P. cris- 10% V. am - 10%
G2	July 27	2.4	b	16,054.6 58,978.9	1133	1121	C. dem - 75% H. dub - 25%
G3	July 27	2.7	b	16,054.6 58,978.9	367	500	Chara - 85% V. am - 15%

Appendix A (cont'd): Biomass Sampling Results - Cook's Bay Macrophyte Survey, 1987

Sample Station	Date	Depth (m)	Secchi Depth (m)	Loran C Coords.	Wet Volume (ml/m^2)	Wet Mass (g/m^2)	Species Composition
G4	July 27	2.7	b	16,054.5 58,977.6	520	603	Chara - 85% V. am - 15%
G5	July 27	2.5	b	16,054.4 58,976.9	387	472	Chara - 90% V. am - 10%